Technical Memorandum

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Subject: Development of Modeling Files for the Mexico NEI, Six Northern States

Date: February 2, 2006

1.0 INTRODUCTION

Subsequent to early efforts in the 1990s by the Grand Canyon Visibility Transport Commission and the WGA to build emissions inventory capacity in Mexico, a project to develop the first comprehensive national emissions inventory for the country of Mexico began in 2000. The Mexico National Emissions Inventory (NEI) project has financial support of the WGA, U.S. EPA, Mexico's Secretariat of the Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales – SEMARNAT*) and National Institute of Ecology (*Instituto Nacional de Ecología – INE*), and the North American Commission for Environmental Cooperation (CEC). Representatives from these partners, along with other stakeholders from government, academia, and private sector entities on both sides of the U.S./Mexico border, provide technical guidance for the development of the Mexico NEI.

The project to develop the Mexico NEI has been conducted in three phases. Phase I focused on organizing a technical advisory committee and developing the Inventory Preparation Plan[1]. Phase II covered the development of the inventory for the six northern states[2]. Phase III, which is still under development, has resulted to date in the draft final version of the inventory for the entire country (i.e., 32 states and 2,444 municipalities)[3]. The final version of the Mexico NEI will be completed in March 2006.

The objectives of the Mexico NEI are as follows:

- Provide an improved technical basis for improved air quality analyses within Mexico and along both sides of its borders;
- Support institutional capacity building to compile, maintain, and update emissions inventories;

[1] *Emissions Inventory Preparation Plan for the Mexico National Emissions Inventory, Final.* Prepared for WGA, U.S. EPA, CEC, and SEMARNAT by Eastern Research Group, Inc., June 16, 2003.
[2] *Mexico National Emissions Inventory, 1999: Six Northern States.* Prepared for WGA, U.S. EPA, CEC, and SEMARNAT by Eastern Research Group, Inc., April 30, 2004. http://www.epa.gov/ttn/chief/net/mexico.html
[3] *Mexico National Emissions Inventory, 1999. Draft Final.* Prepared for WGA, U.S. EPA, CEC, and SEMARNAT by Eastern Research Group, Inc., November 18, 2005.

- Comply with the Mexican Federal Environmental law mandating development and maintenance of a national emissions inventory;
- Assist with regional haze requirements in the United States; and
- Support the development of a tri-national emissions inventory of criteria pollutants for Mexico, the United States, and Canada.

The purpose of this memo is to document the work sponsored by the WRAP for development of air quality model input files of the Phase II (Border States) Mexico NEI. This was conducted by Eastern Research Group, Inc. (ERG) under Task 13 of WGA Contract 30421-4.

The Mexico NEI provides the best available inventory to WRAP, the other Regional Planning Organizations (RPOs), and U.S. EPA for air quality modeling purposes to represent the regional haze baseline planning period 2000 to 2004. WRAP intends to use the 1999 Mexico NEI data for visibility modeling. Also, in the absence of future year projections (including surrogates or scalars), it is the intention of WRAP to hold these emissions constant for purposes of year 2018 modeling. Other information provided under this contract will be used to develop spatial surrogates and grid the Mexican emissions. The Mexico NEI, the gridded emissions, and the underlying surrogates will be publicly available for use by the Mexican government, RPOs, U.S. EPA, and U.S. states.

The remainder of this memo discusses the scope, and summarizes the methods and results pertaining to the Mexico NEI for the six northern border states. Also, the procedure followed to develop the modeling files is described below along with a list of deliverables and their status. This memo accompanies the submittal of the Mexico NEI files in IDA format to SEMARNAT and the WRAP RMC.

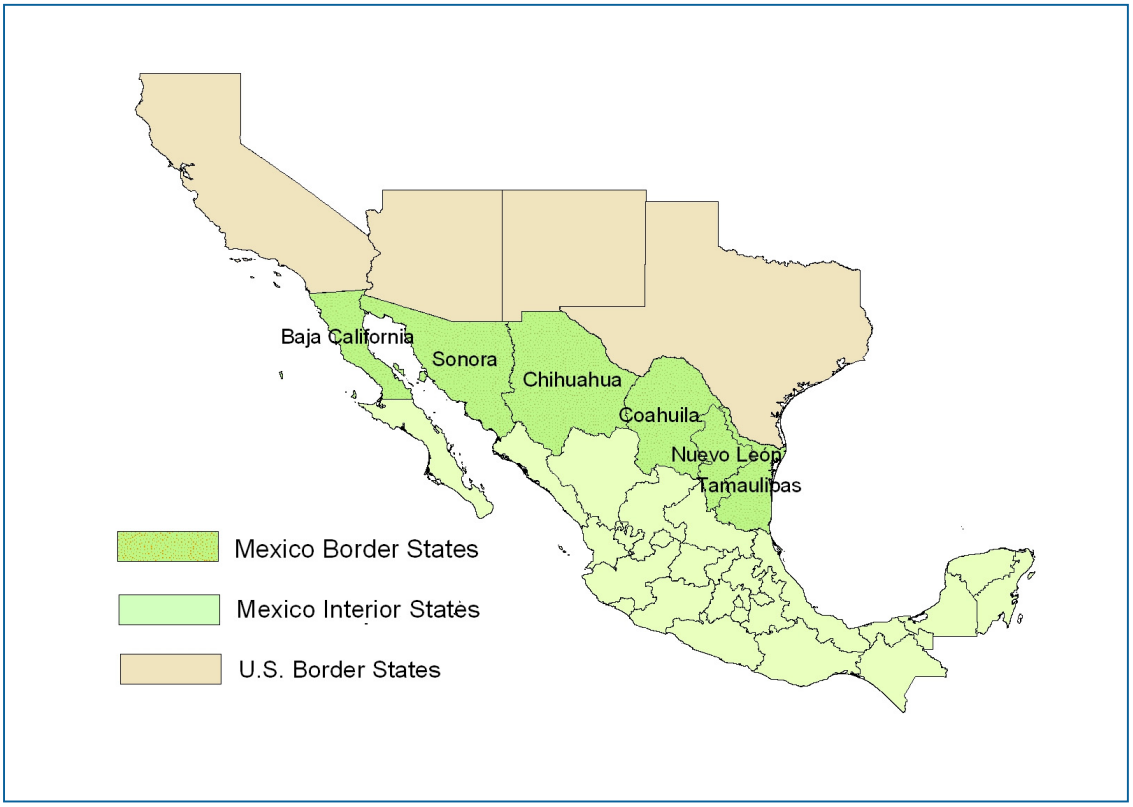
2.0 MEXICO NEI FOR THE SIX NORTHERN BORDER STATES

The characteristics of the Mexico NEI are as follows:

- The base year is 1999. This year was chosen because it was believed that most governmental agencies would possess complete sets of the types of data needed to estimate emissions for that year. Also, the year of 1999 corresponds with EPA's NEI triennial reporting cycle.
- The geographical domain is the 32 Mexican states. Figure 1 shows the country of Mexico and the state boundaries, and highlights the six northern Mexican states of Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas, which are the only states included in the modeling files for WRAP. Emissions are provided at the state and municipality (county-equivalent) level.
- Emissions include nitrogen oxides (NO_x), sulfur oxides (SO_x), volatile organic compounds (VOC), carbon monoxide (CO), particulate matter less than 10 micrometers (μm) in aerodynamic diameter (PM_{10}) and less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$), and ammonia (NH_3).
- Source types include point, area, on-road motor vehicle, nonroad mobile, and biogenic sources.

Because of the Mexico NEI has been developed in phases, and due to changes that have occurred in methods, data, and other factors over the past five years that the inventory has been developed, several versions exist. The Mexico NEI results contained in the draft final Mexico NEI report are tracked internally by ERG as Version 2.0[3]. While Version 2.0 emissions for area, on-road motor vehicles are contained in the IDA files that were submitted to the WRAP RMC under this contract, the point and nonroad mobile emissions are Version 2.1 due to several changes that were made to

Figure 1. Mexico NEI Domain for the Six Northern States



these categories since the draft final report was published. Therefore, the files that have been provided to the WRAP RMC represent the most current estimates for the Mexican border states. (Note that a special condition exists for the biogenic emissions, which is discussed below in Section 2.5.)

The following sections present a brief summary of the methods and results pertaining to the individual source types. Please refer to the draft final Mexico NEI report for details on methods and data used[3].

2.1 Point Sources

For the Mexico emissions inventory, a decision was made to classify industrial point sources based upon the jurisdiction under which the facility operates. The point source inventory included those industrial facilities under federal or state jurisdiction. The point source inventory for the six Border States included only facilities that emit 10 tons/year or more of total pollutants.

Federal jurisdiction point source categories include industrial facilities in the following 11 sectors, plus industrial facilities that are located with "federal zones" (regardless of sector):

Petroleum extraction and petroleum/petrochemical manufacturing	Electrical energy generation
Chemical manufacturing	Hazardous waste treatment
Paints and inks manufacturing	Facilities located within federal zones: • Federal airports, train and bus stations, ports, and transportation systems • Industrial parks located on federal land • Within 25 kilometers (km) of any coastline • If impacting other states or countries • Within Mexico City metropolitan area
Metal products manufacturing	
Automotive parts manufacturing	
Pulp and paper manufacturing	
Cement and lime manufacturing	
Asbestos mining and manufacturing	
Glass manufacturing	

State jurisdiction point sources are industrial facilities not included within the 11 federal sectors and not located within a federal zone. Generally, industrial facilities under state jurisdiction include operations that a state requires to obtain and update an operating permit. The types of industries required to obtain permits are determined at the discretion of the state environmental agency (SEA); therefore, the categories considered to be point sources may vary between states. For the purpose of the Mexico emissions inventory, all facilities under federal or state jurisdiction were considered to be point sources.

For the six northern Mexican states point source emissions inventory, criteria emissions except ammonia (NH_3), were estimated for approximately 579 facilities. Table 1 lists the number of point source facilities included in the Mexico NEI by state.

Table 1. Point Source Facilities by State

State Name	Number of Point Source Facilities
Baja California	157
Coahuila	50
Chihuahua	113
Nuevo León	141
Sonora	52
Tamaulipas	66
Total for Six Northern States	**579**

The point source data, including the emissions estimates, facility location, and geographic coordinates were taken from the Mexico NEI. For most of these facilities, the coordinates were reported by the facility and in cases of erroneous or missing data, ERG gap filled any missing coordinates using the locality (community equivalent) centroid in which the facility was located.

Current Mexican law allows public access to emissions data (i.e., facility name, NAICS, facility location, stack parameters, and annual emissions) only for industries under federal jurisdiction. Out of the total 579 facilities in the six northern Mexican Border States, 486 were under federal jurisdiction. Even though current Mexican law allows the release of such data for the industries under federal jurisdiction, it was still necessary to receive permission from SEMARNAT to do so. Specifically for this WRAP contract, ERG assisted with obtaining official release of facility-level information for developing modeling-level emissions for the WRAP project.

However, for the remaining 93 facilities not under federal jurisdiction, it was not possible to disclose the real identity of the facility, including facility name, and applicable NAICS codes, location, etc. Originally, ERG's scope of work called for these to be treated as area sources, however, another solution was developed which allowed these to be treated as point sources after all. For these, ERG retained the original NAICS codes where there were 4 or more facilities within

one municipality that had the same NAICS code. In the case of fewer than 4 facilities, an NAICS code of 339999 and SCC 399900 (all other miscellaneous manufacturing) was assigned to the manufacturing facilities. In the case of fewer than 4 non-manufacturing point sources, a SCC 399999 (miscellaneous industrial process) was assigned. Also, the name of each of the nonfederal jurisdiction facilities was given as "Undisclosed" in order to maintain confidentiality of the facility identity.

Table 2 summarizes the point source emissions for the six northern Mexican Border States. It should be noted that the results shown in Table 2 differ slightly from the results reported in the draft final Mexico NEI report. The reasons for this are that some changes were made to the emissions during the process of assigning stack parameters, and also that the emissions are reported in units of megrams (Mg) per year in the draft final Mexico NEI report. This is explained in more detail, in Section 3.0 of this memorandum.

Table 2. State-level Point Source Emissions (Tons/Year) (Ver. 2.1)

State Name	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$
Baja California	6,580.2	29,326.7	18,353.3	873.5	5,178.0	4,243.6
Coahuila	142,733.2	182,347.1	6,198.5	19,900.3	29,337.3	28,315.6
Chihuahua	19,988.8	71,857.0	3,188.8	15,235.8	7,982.3	6,908.3
Nuevo León	22,646.7	90,400.7	24,624.1	24,379.6	12,110.4	10,748.2
Sonora	14,290.8	173,367.9	1,782.7	3,468.8	34,040.2	16,244.5
Tamaulipas	16,786.6	167,403.6	29,597.6	12,940.1	6,936.0	4,701.4
Border States Total	**223,026.3**	**714,703.0**	**83,745.0**	**76,798.1**	**95,584.2**	**71,161.6**

2.2 Area Sources

The area source emissions estimates for the Mexico NEI consisted of 46 different categories. The different area source categories included in the Mexico NEI are listed in Table 3. Locomotive, aircraft, and commercial marine emissions are also included as area source categories in the Mexico NEI. Some important area source categories that have been excluded from the Mexico NEI due to unavailability of data are paved and unpaved road dust, landfills, and wind erosion.

Table 3. Area Source Categories Included in the Mexico NEI

Fuel combustion: industrial, commercial, residential, agricultural, and transportation sectors	Nonroad sources: locomotives, commercial marine vessels, and aircraft
Border crossings	Charbroiling and street vendors
Consumer solvent use	Fertilizer application
Surface coatings: industrial and architectural	Pesticide application
Autobody refinishing	Beef cattle feedlots
Degreasing	Construction activities
Dry cleaning	Agricultural burning
Graphic arts	Agricultural tilling
Traffic markings	Livestock ammonia
Asphalt application	Open burning: waste
Gasoline distribution	Wastewater treatment
Liquefied petroleum gas (LPG) distribution	Wildfires
Bakeries	Structure fires
Brick kilns	Domestic ammonia

Various fuels included in the fuel combustion categories are residual, distillate, natural gas, LPG, kerosene, and wood. Activity data used to calculate emissions for most of the area source categories was Mexico specific data. U.S data for certain categories was extrapolated to Mexico due to unavailability of Mexico specific data.

After emissions estimates were calculated, the area source inventory was reconciled with the industrial point source inventory to avoid double-counting of point source emissions within the various are source fuel combustion categories. The reconciliation was limited to industrial fuel combustion only; for example, reconciliation of industrial surface coating and solvent use was not carried out due to limited point source information for these categories. Table 4 presents the state-level summary of area source emissions for the six northern Mexican states. Again, note that the emissions shown in Table 4 differ from those reported in the draft final Mexico NEI report due to different units (i.e., Mg/year in the draft final Mexico NEI report).

Table 4. State-Level Area Source Emissions (Tons/Year) (Ver. 2.0)

State Name	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$	NH_3
Baja California	14,015.5	18,647.1	56,534.8	36,769.3	4,734.0	3,251.9	11,153.4
Coahuila	9,479.2	9,824.4	50,661.9	22,207.2	3,778.9	2,254.4	29,389.8
Chihuahua	15,881.2	27,629.7	75,019.7	57,780.6	14,329.9	7,977.6	45,996.2
Nuevo León	7,698.8	17,362.2	72,792.0	25,928.9	5,334.3	3,558.4	24,847.2
Tamaulipas	11,193.6	2,106.9	45,979.9	72,387.5	10,118.2	7,635.6	54,014.2
Sonora	11,805.0	2,680.0	53,692.4	40,784.9	11,157.4	5,280.9	41,109.6
Border States Total	**70,073.3**	**78,250.3**	**354,680.7**	**255,858.4**	**49,452.7**	**29,958.8**	**206,510.4**

2.3 On-Road Motor Vehicles

The on-road motor vehicle source categories included in the Mexico NEI are based upon vehicle classifications that exist within MOBILE6-Mexico emission factor model[4], which was used to estimate motor vehicle emissions. These vehicle classifications are based on vehicle type, fuel type, and gross vehicle weigh rating (GVWR) in pounds (lbs). The 28 MOBILE6-Mexico vehicle classifications were aggregated into the following 7 vehicle classifications, for which emissions were then calculated:

- Light-Duty Gasoline Vehicles (LDGV)
- Light-Duty Gasoline Trucks (LDGT)
- Heavy-Duty Gasoline Vehicles (HDGV)
- Light-Duty Diesel Vehicle (LDDV)
- Light-Duty Diesel Trucks (LDDT)
- Heavy-Duty Diesel Vehicles (HDDV)
- Motorcycles (MC)

[4] *MOBILE6-Mexico.* Prepared for WGA by Eastern Research Group, Inc., June 27, 2003.

The MOBILE6-Mexico emission factor model was used to generate emission factors for all the above listed 7 vehicle classifications. These emission factors were used to calculate daily per capita emission rates based on travel demand models (TDMs) for seven representative urban areas in Mexico. These daily per capita emission rates were then multiplied by municipality population to obtain municipality-level emissions.

Table 5 presents the state level summary of on-road motor vehicle emissions for the six northern Mexican states. Again, note that the emissions shown in Table 5 differ from those reported in the draft final Mexico NEI report due to different units (i.e., Mg/year in the draft final Mexico NEI report).

Table 5. State-level On-Road Motor Vehicle Emissions (Tons/Year) (Ver. 2.0)

State Name	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$	NH_3
Baja California	14,592.9	828.7	17,695.6	135,645.0	697.2	638.8	269.3
Coahuila	11,393.2	650.1	13,897.3	115,726.0	546.6	500.8	186.8
Chihuahua	15,783.9	895.7	19,447.0	161,061.8	753.7	690.6	273.2
Nuevo León	40,349.8	2,144.7	52,457.7	391,393.7	1,804.0	1,652.9	620.8
Sonora	8,714.2	498.5	10,537.3	81,055.1	419.4	384.3	169.5
Tamaulipas	13,527.0	770.0	16,219.4	125,258.4	647.4	593.2	242.0
Border States Total	**104,361.0**	**5,787.7**	**130,254.3**	**1,010,140.0**	**4,868.3**	**4,460.6**	**1,761.6**

2.4 Nonroad Mobile Sources

The Mexico NEI includes agricultural diesel equipment and construction diesel equipment categories in the nonroad mobile source type. As discussed in Section 2.2, above, locomotives, aircrafts, and commercial marine vessels categories are included as area source categories in the Mexico NEI. The equipment classification for the nonroad source categories are based upon NONROAD-Mexico emission factor model[5]. These equipment classifications are based upon engine type, power, and fuel type. Many equipment types feature different fuel options, including diesel, 2- and 4-stroke gasoline, propane (LPG), and natural gas. The NONROAD-MEXICO model also groups engines by horsepower bin, ranging from 1 to over 1,000 horsepower (hp), depending on the application. Table 6 lists the different equipment classifications included in the Mexico nonroad mobile source emissions.

Mexico-specific input data files were developed for running the NONROAD-Mexico model. These files were developed from data obtained from locally conducted nonroad equipment activity studies in Mexico. U.S nonroad equipment data and fuel usage data were extrapolated to Mexico based on certain surrogates like gross domestic product (GDP), kilometers of road, or surface area of construction, etc.

National nonroad emissions were calculated for Mexico using the NONROAD-Mexico model and then these emissions were allocated down to municipalities based on municipality-level agricultural tractor population for diesel agricultural equipment category and municipality-level population for construction equipment category.

[5] *Nonroad-Mexico: A Tool for Estimating Emissions from Agricultural and Construction Equipment in Mexico, Final.* Prepared for WGA and the Binational Advisory Committee by Eastern Research Group, Inc. November 11, 2005.

Table 6. Nonroad Equipment Classifications Included in the Mexico NEI

Construction Equipment		Agricultural Equipment
Pavers	Cranes	2-wheel tractors
Tampers/rammers	Graders	
Plate compactors	Off-highway trucks	Agricultural mowers
Rollers	Crushing/processing equipment	Agricultural tractors
Scrappers	Rough terrain forklifts	Balers
Paving equipment	Rubber tire loaders	Combine
Surfacing equipment	Rubber tire tractors/dozers	Hydraulically-powered equipment
Signal boards/light plants	Tractors/loaders/backhoes	
Trenchers	Crawler tractors/dozers	Sprayers
Bore/drill rigs	Skid steer loaders	Swathers
Excavators	Off-highway tractors	Tillers >6 horsepower
Concrete/industrial saws	Dumpers/tenders	Irrigation pumps
Cement and mortar mixers	Other construction equipment	Other agricultural equipment

Table 7 presents a state-level summary of emissions from nonroad mobile source categories for the six northern Mexican Border States. It should be noted that the results shown in Table 2 differ slightly from the results reported in the draft final Mexico NEI report[3]. The reason for this is that some changes were made to the nonroad emissions after the draft final report was published, due to a change in the value used for sulfur content of diesel fuel.

Table 7. State-Level Nonroad Mobile Source Emissions (Tons/Year) (Ver. 2.1)

State Name	NO_x	SO_x	VOC	CO	PM_{10}	$PM_{2.5}$
Baja California	10,540.1	140.1	1,189.7	5,549.3	1,272.7	1,234.6
Coahuila	9,154.5	122.5	1,014.7	4,759.9	1,091.6	1,058.8
Chihuahua	10,464.1	140.2	1,120.5	5,341.5	1,211.8	1,175.5
Nuevo León	14,282.1	190.7	1,550.5	7,360.5	1,677.6	1,627.3
Sonora	11,299.8	148.4	1,430.3	6,373.6	1,502.4	1,457.3
Tamaulipas	20,262.5	259.7	2,863.3	12,277.9	2,951.6	2,863.1
Border States Total	**76,003.1**	**1,001.6**	**9,169.0**	**41,662.7**	**9,707.7**	**9,416.6**

2.5 Biogenic Sources

The Mexico NEI includes emissions of natural sources, which are defined as being either biogenic or geogenic. Biogenic source include VOC emissions from forests and crops as well as soil NO_x emissions. Geogenic sources include volcanoes, although no active volcanoes are located within the six northern Mexican states. The Global Biosphere Emission and Interactions System (GloBEIS) Version 3.1 was used to estimate biogenic emissions for the Mexico NEI[6]. This model used domain definitions, meteorological data, and land use data collected from various sources in Mexico and the U.S.

Table 8 summarizes the state level biogenic emissions for the six northern Mexican states. For the WRAP task, ERG did not develop IDA files of the biogenic emissions, but instead provided the GloBEIS model input and output files, along with the GIS shape files used in the GloBEIS model to

[6] *User's Guide to the Global Biosphere Emissions and Interactions System (GloBEIS3), Version 3.0.* Prepared fro the Texas Commission on Environmental Cooperation (TCEQ) by ENVIRON International Corporation. 2002. http://www.globeis.com

Table 8. State-level Biogenic Emissions (Tons/Year) (Ver. 2.0)

State Name	NO_x	VOC
Baja California	4,040.7	16,918.9
Coahuila	56,334.9	341,264.7
Chihuahua	46,919.7	1,748,270.3
Nuevo León	35,405.1	240,920.2
Sonora	51,362.9	715,143.7
Tamaulipas	72,050.7	423,180.0
Border States Total	**266,114.0**	**3,485,697.8**

the WRAP RMC. These data, and the summary in Table 8, can be used to quality assure the biogenic emissions generated within SMOKE by the WRAP RMC for the six northern Mexican states.

3.0 MODELING FILES DEVELOPMENT

Formatting of the area, on-road motor vehicle, and nonroad files was very straightforward. The emissions data were formatted into both National Emissions Inventory Format (NIF) version 3.0, and IDA formats.

However, even after performing the gap filling for SCCs and location coordinates as described above for point sources, several issues still needed to be resolved pertaining to the point sources. These issues were due mainly to the fact that the Mexico NEI point source inventory was developed at the facility level and no individual stack data were readily available. To remedy this, several steps were performed. First, ERG assigned six-digit SCC codes to each facility record, based on their corresponding NAICS codes. These codes were incorporated into the IDA files and sent to the WRAP RMC. The WRAP RMC used SMOKE to perform some initial processing, including assigning default stack parameters based on six-digit SCC. (The WRAP RMC had developed the six-digit SCC defaults by compiling the U.S. EPA eight-digit defaults and calculating the median default for each of the SCCs in the Mexico NEI data set.)

Once this assignment was complete, the data were sent to SEMARNAT for their review and comment. Several changes were made by SEMARNAT to replace some of the default stack parameters with actual stack data for certain facilities, as well as to add several new emission units/stacks to certain facilities. ERG incorporated these changes into the point source NIF and IDA files.

4.0 DELIVERABLES

The status of work products/deliverables to be completed by ERG are listed in Table 9. All work must be completed by March 31, 2006.

Table 9. Status of ERG Work Products/Deliverables for Task 13

Work Product/Deliverable	Status
Obtain final Mexico NEI for the border states and facilitate release of the point source data with SEMARNAT	Complete
Convert nonfederal point source data to area format	Complete (retained as point sources with undisclosed facility names)
Gap fill SCCs and geographical coordinates	Complete
Coordinate with the WRAP RMC: Stack parameters	Complete
Coordinate with WRAP RMC: Temporal profiles	In Progress
Coordinate with WRAP RMC: Spatial surrogates	Complete (border crossings, railways)
Submit IDA files to WRAP RMC	Complete
Submit NIF files to WRAP EDMS	Complete
Submit draft report	Complete (memorandum)
Submit final report	Complete (memorandum)
Facilitate review of modeling results by SEMARNAT	In Progress